Grant agreement no. EIE/06/078/SI2.447511
Project acronym: **Gasification Guide**
Full title of the action: Guideline for safe and eco-friendly biomass gasification
Intelligent Energy – Europe (IEE)
Key action: ALTENER

Deliverable D11:

Software Tool
Risk Analyzer (beta) - User Manual

Software **Beta** version, November 2007-12-10

DRAFT VERSION

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The project is co-funded by the European Commission.

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Foreword

The software tool RISK ANALYSER was created in 2007 under the "Gasification Guide" project, which is supported by the Intelligent Energy for Europe programme under contract.no. EIE-06-078.

Biomass gasification is a promising technology, which can contribute to the overall EU-policy to develop future energy systems which are efficient, safe in design and operation as well as environmental friendly and increase the share of renewable energy. Gasification technology is near to commercialisation but today large-scale introduction is hampered by various reasons.

Poor awareness and lack of understanding of the Health, Safety and environment (HSE) hazards in the project development, planning, design, construction stage and during operation and maintenance of gasification plants is recognized as a major non-technical obstacle. The project "Guideline for Safe and Eco-friendly Biomass Gasification" aims to effectively tackle this barrier.

The objective is to accelerate the market penetration of relatively small scale biomass gasification systems (< 5 MW_{Fuel}) by the development of a Guideline and Software Tool for easy and simple risk assessment of HSE.

The project homepage can be reached at http://www.gasification-guide.eu.

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1. Software tool RISK ANALYSER

1.1. Objective and target group

The generation of the software tool is part of the "Gasification Guide" project (EIE-06-078) [1], with the objective to accelerate the market penetration of relatively small scale biomass gasification systems (< 5 MW_{Fuel}) for the decentralises energy supply systems based on renewable sources.
Together with the development of a guideline, the software tool facilitates the assessment of health, safety and environment (HSE) issues of small scale biomass gasification plants. The target group of the software tool are in the first place operators, manufacturers, project developers, researchers, and implementers of biomass gasification plants.
Since the software is created generally open, in order to be used for any gasification technology and process chain (compare with the “technology description” in the guideline, also generated in this project), it can moreover also be used for other processes than biomass gasification.

1.2. Method

From literature there are many possible approaches regarding risk assessment procedures available [2-4]. The substantial differences between these methods often lie in the basic approach and the degree of exactness of the reachable results.
Biomass gasification in small and medium scale systems is partly a unique technology where no explicit techniques and no guidance for the conduction of risk assessment are available.
This software provides a recommended risk assessment procedure, which is practicable and sufficient for the application in biomass gasification plants. The chosen method bases on a HAZOP study and is enlarged by additional features which are demanded by the application in biomass gasification plants. The method for the risk assessment which is implemented in this software tool is described in detail in other reports of the project and in the draft guideline as well as in the final guideline later on.

1.3. Required preparation and documents by the user (group)

Risk identification and assessment is a very extensive work, where one needs to be aware of the process, its behaviour and the risk assessment methodology itself. A general suggestion is that risk assessment should be done in team-work, since creativity is enhanced and oversight of possible hazards can be reduced. Prior to starting the software aided risk assessment the following points should be prepared:

- plant data (process schemes, piping and instrumentation diagram (P&I), plant part reference designation codes, apparatuses design, etc.)
- predefined plant operation modes (knowledge about start-up, shut-down and normal operation mode), process control strategies
- desired operation conditions (temperature, pressure, flows and expected gas compositions)
- machinery lists, details construction drawings
- mass and energy balances, process stream information (composition and pollutant load)

The above process information should reasonable be fed into the software by a single person, before starting the risk assessment by the team.

2. Installation and system requirements

2.1. System requirements

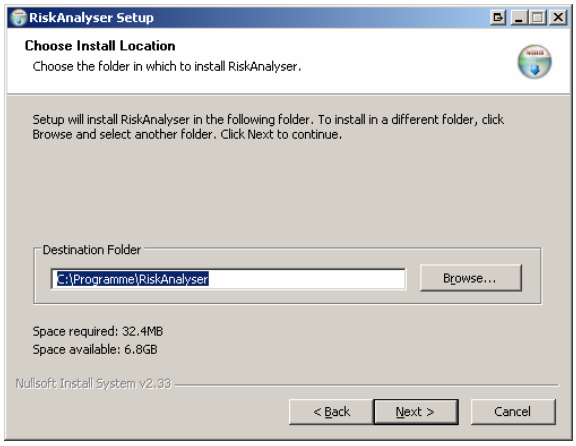
The software RISK ANALYSER is programmed for the Java runtime environment. Java has to be installed in order to run RISK ANALYSER.
The system requirements are:

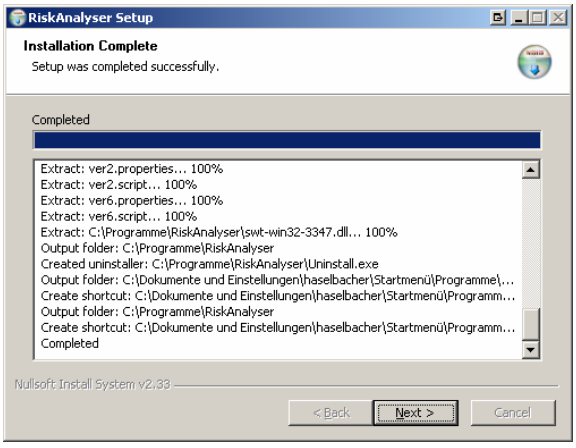
- Intel® Pentium® III or equivalent processor
- Microsoft® Windows® Vista; Windows XP (or Tablet PC Edition); Microsoft Windows 2000;
  512 MB of RAM
- Java runtime environment
  download Java from: http://www.java.com/en/download/

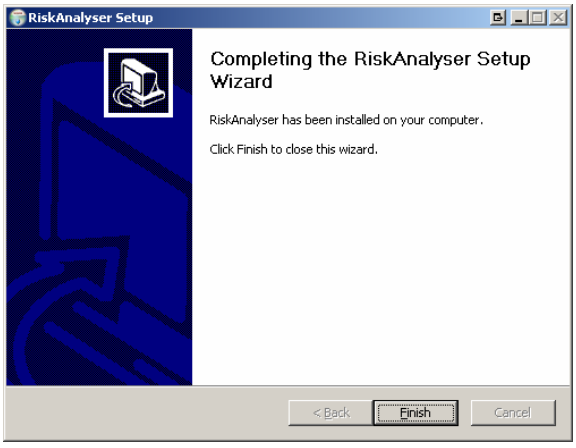
Since Java is platform independent, the software will be available for all other operating systems in the future.

2.2. Installation procedure

RISKANALYSER comes with a (multi-language) self-installer (setup.exe), which is shown for Windows in the following.







2.3. Start Programme

The programme Risk Analyser can be started via:
Start → Programs → RiskAnalyser → RiskAnalyser

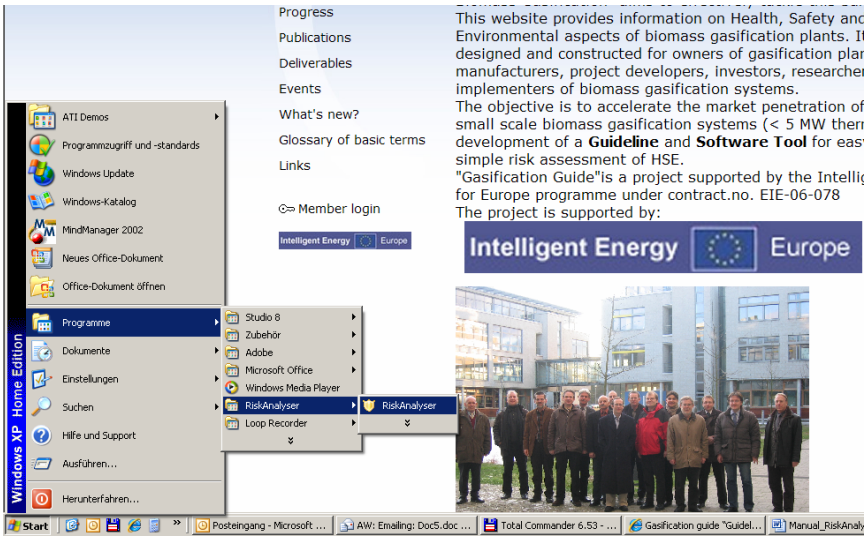


Figure 2-1: Windows Start menu for starting the Riskanalyser

2.4. Uninstall

The uninstaller can be reached via :
Start → Programs → RiskAnalyser → Uninstall RiskAnalyser

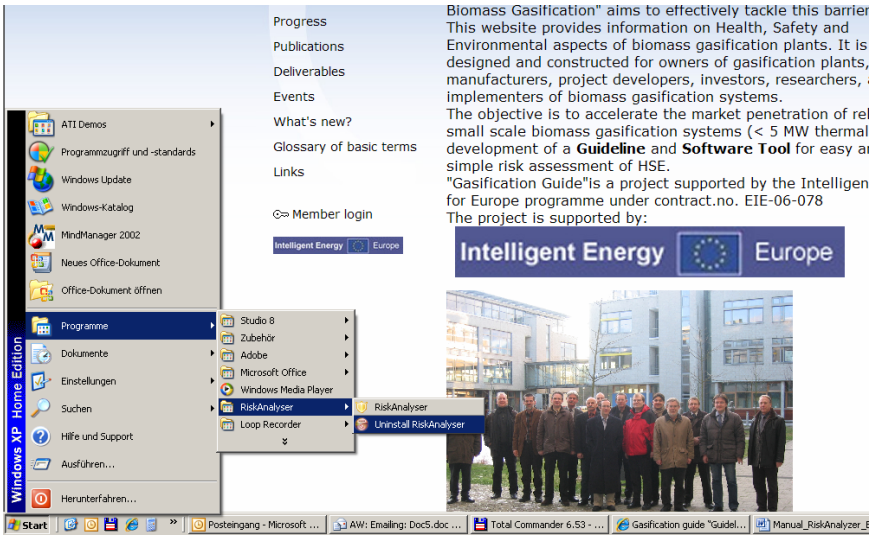


Figure 2-2: Windows Start menu for uninstalling the Riskanalyser

3. General descriptions

3.1. Structure and hierarchy of the implemented database

During the definition of the process and the gasification plant the following hierarchy has to be used.

1. Process units (top):
2. Functions (of a process unit):
3. Units (needed to fulfil a function, and so belonging to the function):

For better clarity, the whole process has to be divided into process units (e.g. gasifier, or gas scrubbing). Every process units is subdivided into functions (e.g. cooling of the gas). Subsequently units (i.e. plant parts) are assigned for each function.

3.2. Reference designation (function and unit codes)

Each process function and unit is designated in the software tool by a code. It is recommended to use a structured designation system according to latest international standardisation for power plants, i.e. IEC 61346-1 “Structuring principles and reference designation”, and the RDS-PP (reference designation system for power plants) respectively [5, 6].

4. Definition of the process and the gasification plant

4.1. Project selection and management

RISK ANALYSER stores all information (all projects, all default settings, etc.) in one or more database files.
This file is stored in e.g. <ProgramDirectory>\db and is called e.g. “database”. Any new project will be saved into the selected database, given on the starting screen.
The first screen of RISK ANALYSER allows the management of databases and projects within a database file (Fig. 1).
The procedure is

1. Create/delete databases: In the background a database will be created or deleted)
2. Select and open a database: The user has to select the wanted data base, via mouse click and opens the database by selecting “Open database”. The different projects (maybe different gasification plants) within this data base will be shown in the window below.
3. Create new project, or open or delete an existing project: When a data base was activated and open existing project within the data base can be added, opened or deleted.

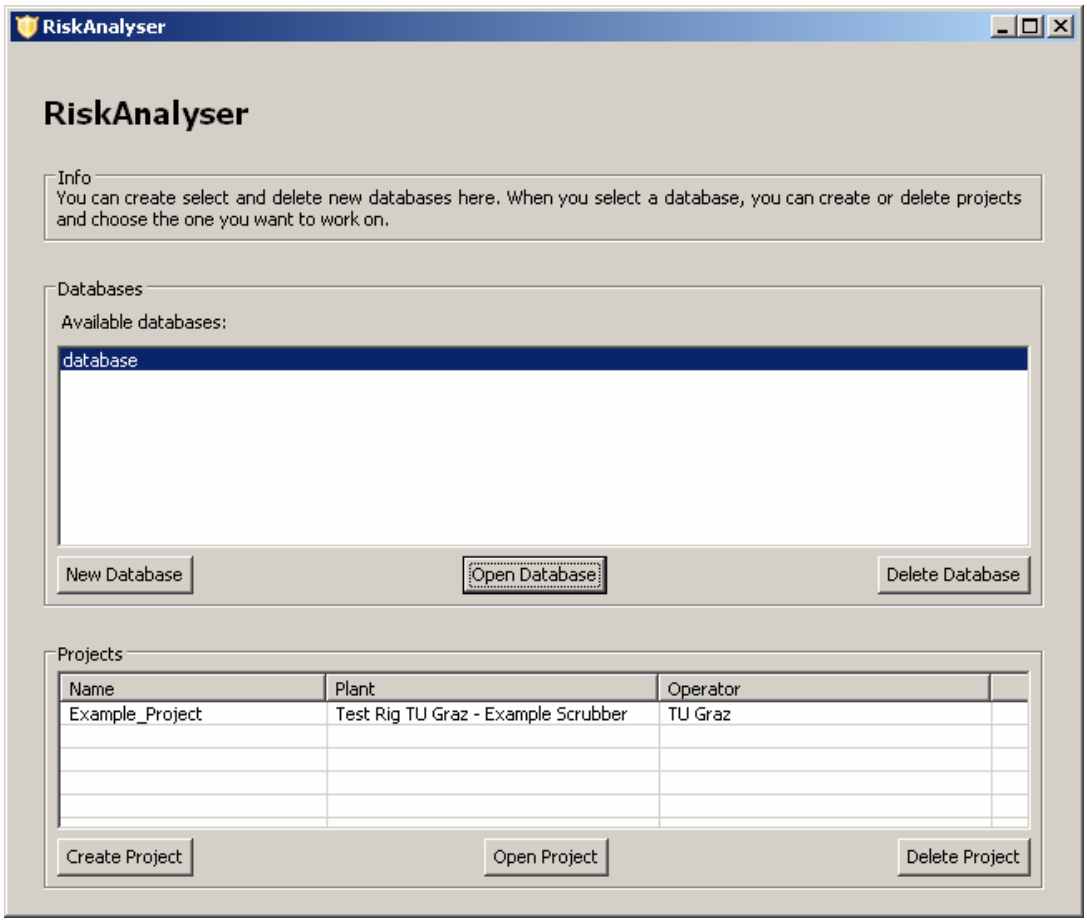


Fig. 1: Front Screen: Database and project management

After opening a project (here: “Example_Project”), the basic information of the project and the evaluated gasification plant can be filled in into the window “Basic Data” (Fig. 2). Data for manufacturer, operator and the plant power and performance are requested. Data is saved with the button “Save Data”.

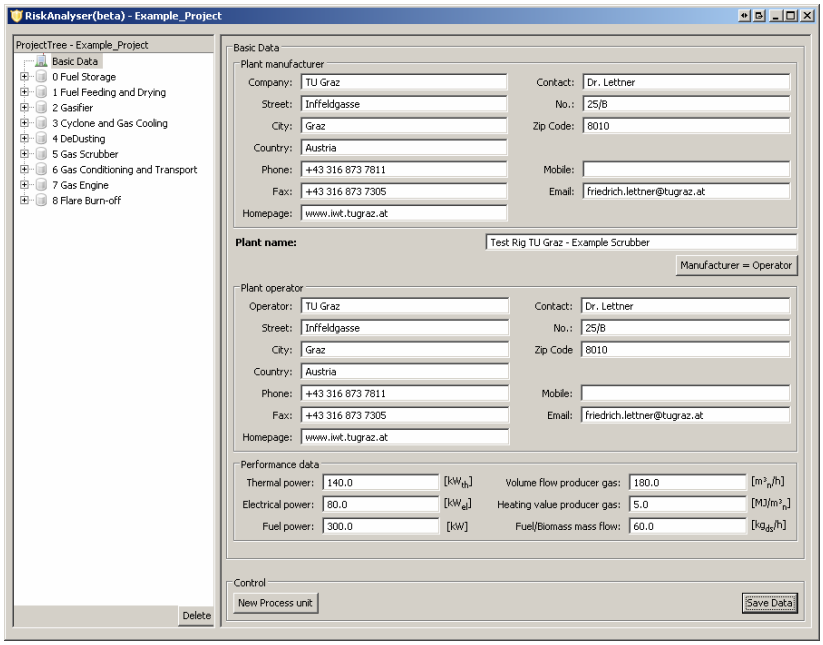


Fig. 2: Basic Data of the project and the gasification plant

4.2. Definition of process units

The next step is the definition of process units.
The procedure is

1. Click “Basic Data” in the Project Tree (Left part of the screen).
2. Click “New Process Unit” in the Control area of basic data window (bottom left)
3. Create new process unit.

Each process unit must have a name and a code. The code can be taken e.g. from the piping and instrumentation diagram for example (P&I diagram).

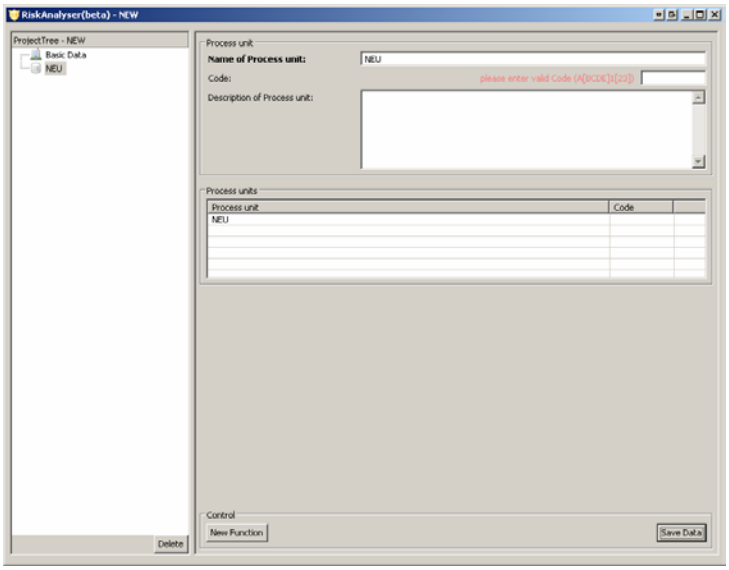


Fig. 3: New process unit

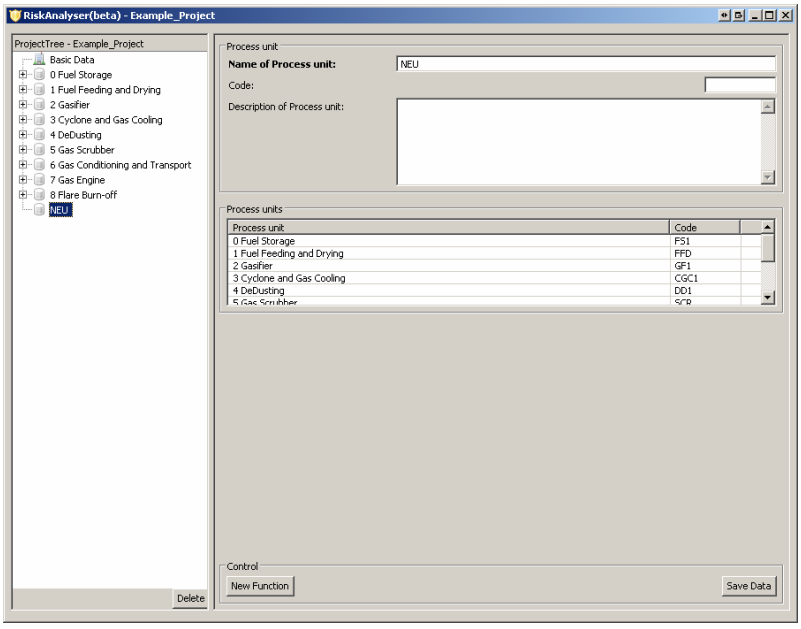


Fig. 4: Example for the definition of process units for a typical gasification plant

A selected function can be deleted by the usage of the delete button.

! Warning: The “Delete-Button” removes the selected data irrecoverable. A undo-function is not implemented. If the foremost process unit is selected and deleted all sub-items and information will be lost!

4.3. Definition of functions for each process unit

Every process unit is subdivided into functions. To define new functions, the procedure is

1. Click on the respective process unit for which the function should be defined (e.g. Gas Scrubber) in the project tree
2. Click “New Function” (control area of process unit window - bottom left)
3. Create new function.
4. Assign name and code (at least)
5. Press “Save Data”

This is shown for the process unit “Gas Scrubber” in Fig. 5, where the following functions were defined exemplarily:

- Gas scrubbing and transport
- Scrubbing media circulation
- Scrubbing media treatment
- Scrubbing media recirculation and waste water treatment

Again functions must have a name and a code. For each function a general description is required as well as a description for the plant operation modes (verbally in the respective text fields). The operation modes are

- Normal mode,
- Start-up,
- Shut-down,
- Emergency stop.

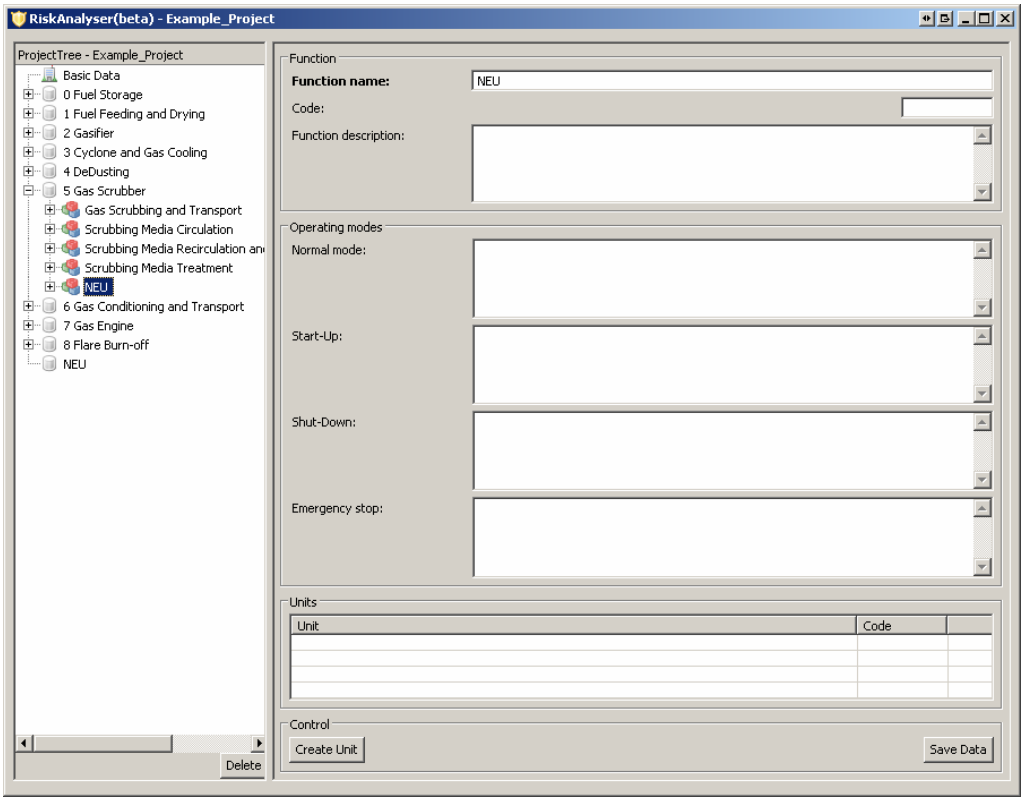


Fig. 5: Definition of functions for a process unit

4.4. Definition of units (for each function)

Every function consists of units (i.e. plant parts). The defining procedure is

1. Click on the respective function for which the unit should be defined (e.g. “Gas Scrubbing and Transport”) in the project tree
2. Click “New Unit” (control area of function window - bottom left)
3. Create new unit
4. Assign name and code (at least)
5. Press “Save Data”

This is shown for the function “Gas Scrubbing and Transport” in Fig. 6, where the following units were defined exemplarily:

- Quench
- Scrubber Tank
- Packing material
- Scrubbing column

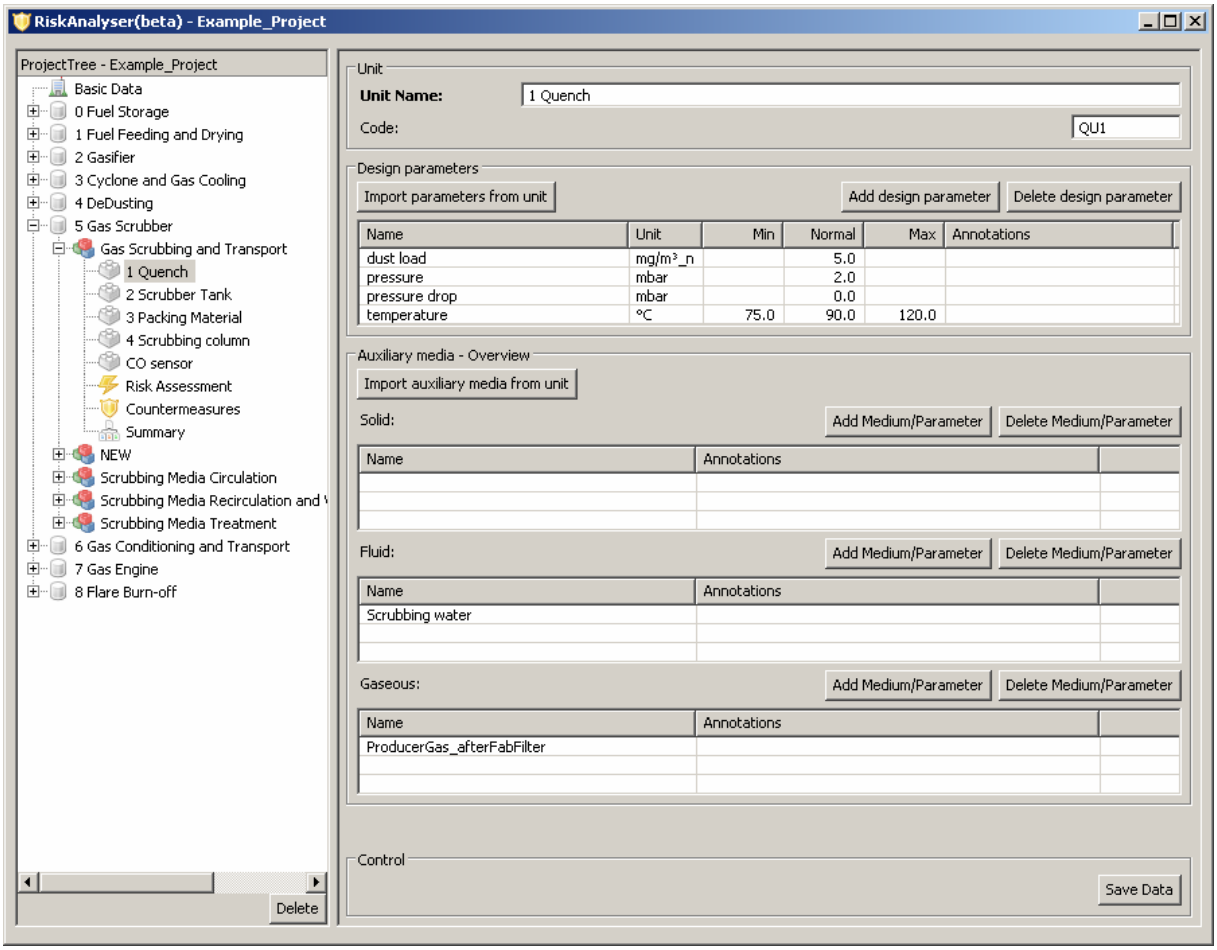


Fig. 6: Definition of units for the function “Gas Scrubbing and Transport” (exemplarily)

Again units must have a name and a code. Units can be assigned with design parameters and auxiliary media (solid, liquid, and gaseous). Exemplarily, these data for unit “Quench” are shown in Fig. 6 as well:
Design parameter for unit “quench”, e.g. temperature: Min: 75°C, Normal: 90°C, Max: 120°C.
Auxiliary media:

Liquid: scrubbing water

Gaseous: producer gas after fabric filter (after process unit de-dusting)

4.5. Definition of design parameters (of units)

The user can define an unlimited number of design parameter for each unit (plant part). By default there is a list of typical design parameters (temperature, pressure, pressure drop, tar and particle load in the producer gas) to choose from. Any other design parameters can be added by the user as necessary by pressing the button “Add design parameter”.
Fig. 7 shows the dialog window for the creation and assignment of design parameters. The procedure is as follows:

1. Creation of a new parameter at the fields to the right
   (e.g. Description: Water content producer gas, and Unit: vol% H_2O_dry basis).
   Pressing “create new design parameters” will add the new parameter to the list of default design parameters at the left
2. Selection of a design parameter in the list
3. By pressing the “Add”-Button, the parameter will be added to the Unit window
4. Apply Min/Norm/Max values to your parameter

Design parameters can easily be imported from existing settings done for other units (Button: “Import parameter from unit” in the unit window).

Deleting of parameters can be done via the “delete”-button.

! Warning: The “Delete-Button” removes the selected data irrecoverable. A undo-function is not implemented!

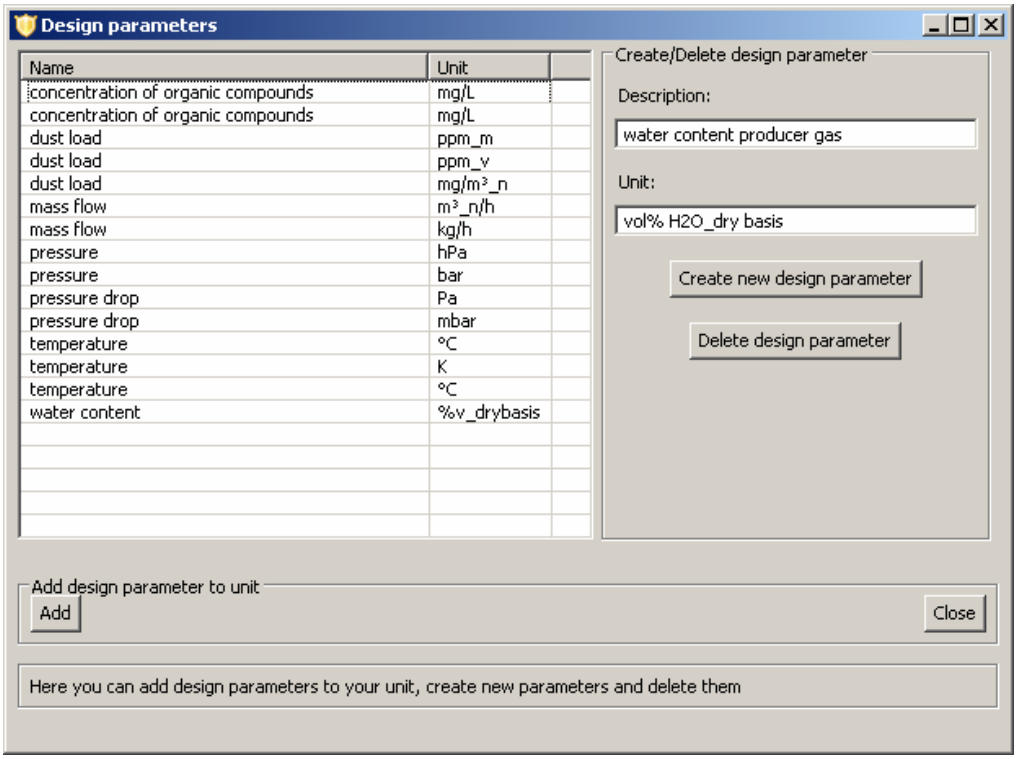


Fig. 7: Definition of design parameters (for units / plant parts)

4.6. Definition of auxiliary media (for units)

The user can define an unlimited number of auxiliary (solid, liquid, and gaseous) media (i.e. process streams) for each unit (plant part) and assign parameters to them. Any process streams can be added by the user as necessary by pressing the button “Add Medium/Parameter”.

Fig. 8 shows the dialog window for the creation and assignment of auxiliary media for units. The procedure is as follows:

1. Creation of a new medium at the field to the right (in the Medium group)
   (e.g. Description: Water content producer gas, and Unit: vol% H_2O_dry basis).
   Pressing the ◄-button will add the new medium (stream) to the drop-down list of stream to the left (hence to the selected unit)

Streams can be assigned with parameters in the following way:

1. Selection of a media from the drop-down list
2. Selection of a media parameter in the list
3. By pressing the “Add Parameter”-Button, the parameter will be added to the media parameter list in the bottom of the screen (hence to the selected media)
4. New parameters can be created in the fields to the right (description and unit), and pressing the ◄-button will add them to the media parameters list (left)
5. Alternatively media parameters can be deleted by the ►-button

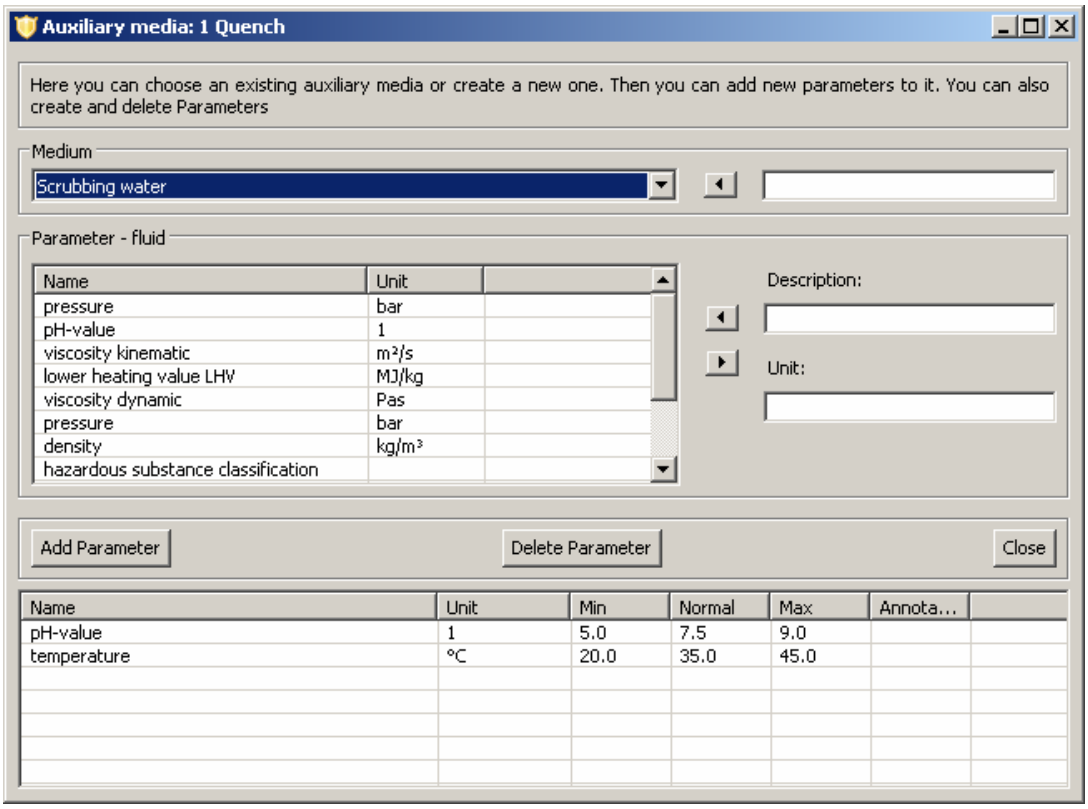


Fig. 8: Definition of auxiliary media streams (for units / plant parts)

After closing the window the user returns to the unit window. Here media parameters can easily be imported including their properties (media parameters) from existing settings done for other units (Button: “Import auxiliary media from unit” in the unit window). Deleting of parameters can be done via the “delete parameter”-button.

! Warning: The “Delete-Button” removes the selected data irrecoverable. A undo-function is not implemented!

5. Risk analysis

5.1. Risk analysis window

Fig. 9 shows the risk assessment window. Risk assessment has to be applied for each process function (here: gas scrubbing and transport), which is selected in the project tree (left). In the upper part of the window a list of all parts which belong to the selected function is shown.
In the lower part of the window lists for events and consequences can be created. The default database contains a list of 36 events and 17 preset consequences, which can be extended by each user as necessary. These two lists can be found in Annex A to this manual (Table I and Table II).

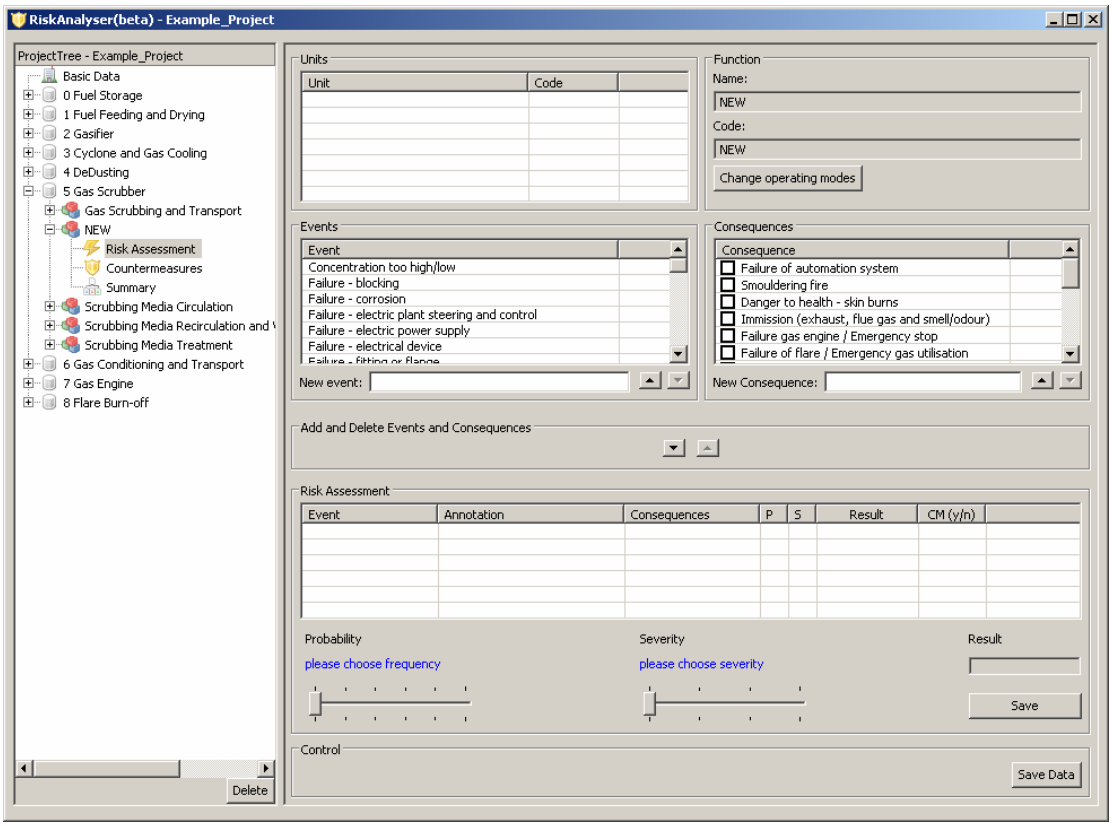


Fig. 9: The risk assessment window

5.2. Definition of events and consequences and risk assessment

The user can define an unlimited number of events and consequences with the fields “New events” and “new consequences” respectively.
The ▲ - button residing left to the “New event”\”New Consequence” text field will add the new event/consequence to the list, the ▼ will delete a marked event\consequence from the list.
The next step is the combination of all possible events in the respective process function with possible consequences. The procedure is indicated in Fig. 10 and explained in the following:

1. Select the event you want to add by clicking on it
2. Select the consequences you want to add to the event by clicking the checkboxes in the consequences window
3. By pressing the ▼ - Button in the 'Add and Delete Events and Consequences' group you add them to the Risk Assessment
4. When the combination is selected (blue background) it can be evaluated with a risk:
5. Selection of a probability (slide bar)
6. Selection a severity (slide bar)
7. Save - Button

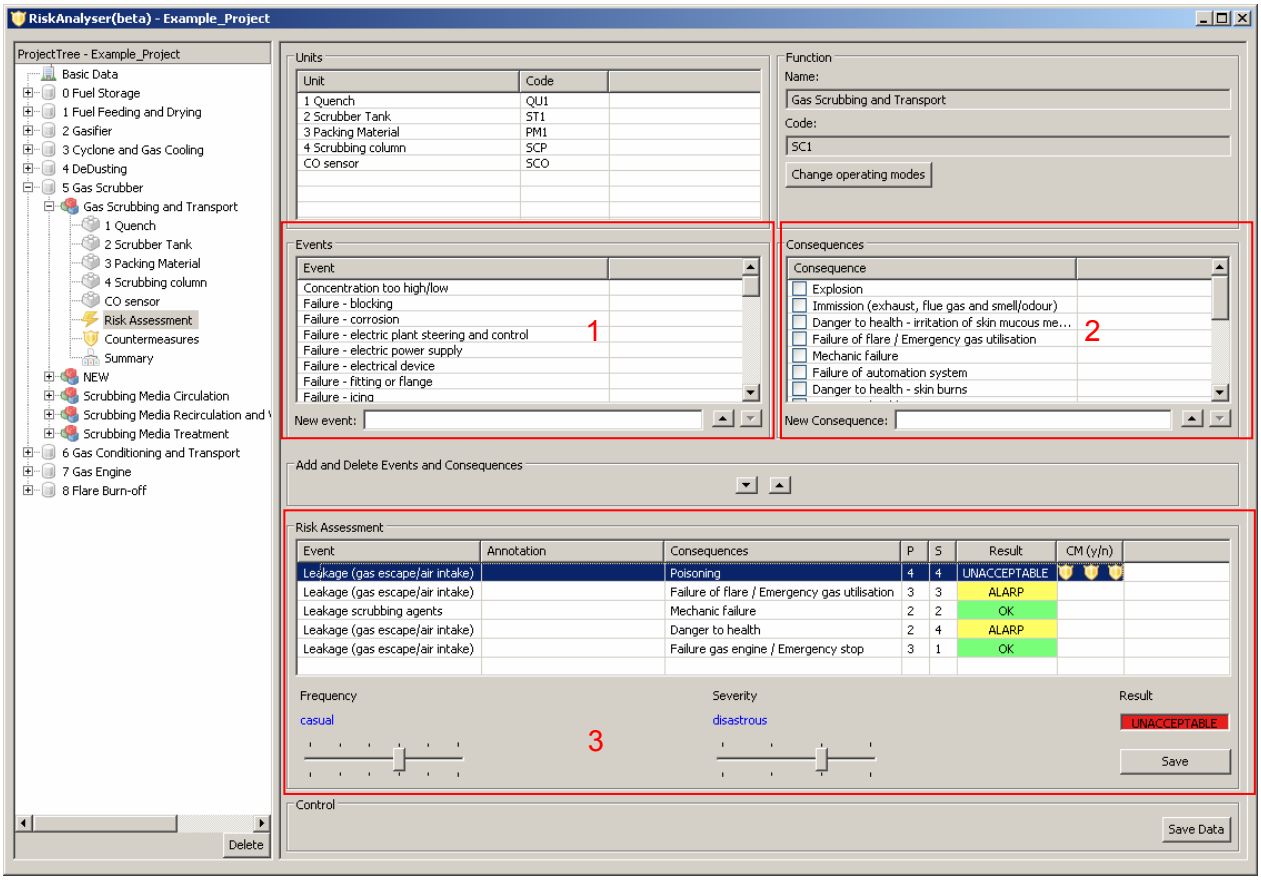


Fig. 10: Definition of events and consequences

According to the combination of probability (i.e. frequency) and severity a risk is associated to each pair of event and consequence. The risk can be "ok", "alarp" or "unacceptable". Alarp stands for "as low as reasonable possible". The implemented risk matrix is shown in Fig. 11. Unacceptable risks have *to* be removed by a countermeasure. Other risks may also be lowered by counter measures.

If a counter measure will be set, the shield-symbol has to be activated in the CM (y/n) column. For unacceptable risks this is activated obligatory.

As long as there are unacceptable risks within a process function, no summary can be created.

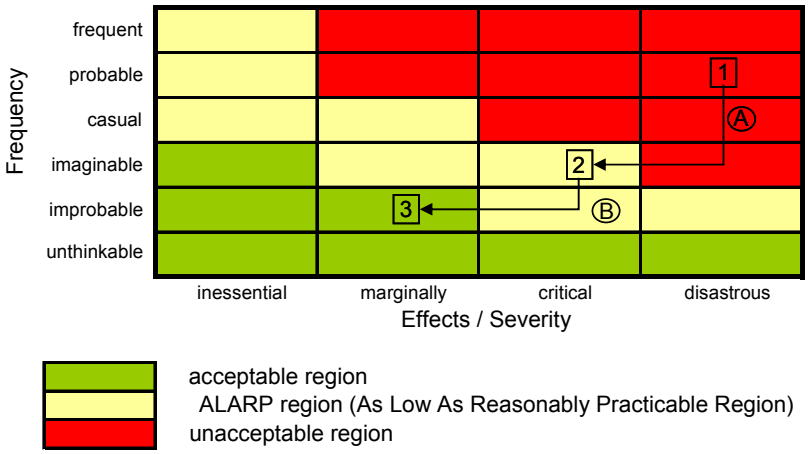


Fig. 11: Risk matrix of frequency vs. severity

During risk assessment, changes in the plant operation may be necessary. These adoption can be described in the “Change operation modes”-window (see Fig. 12), which can be accessed from the risk assessment window. On the left side, you will find your original operating modes. On the left side, you can define new operating modes. If you want to copy one original mode to the left side, click into the mode and press the “Copy” button.

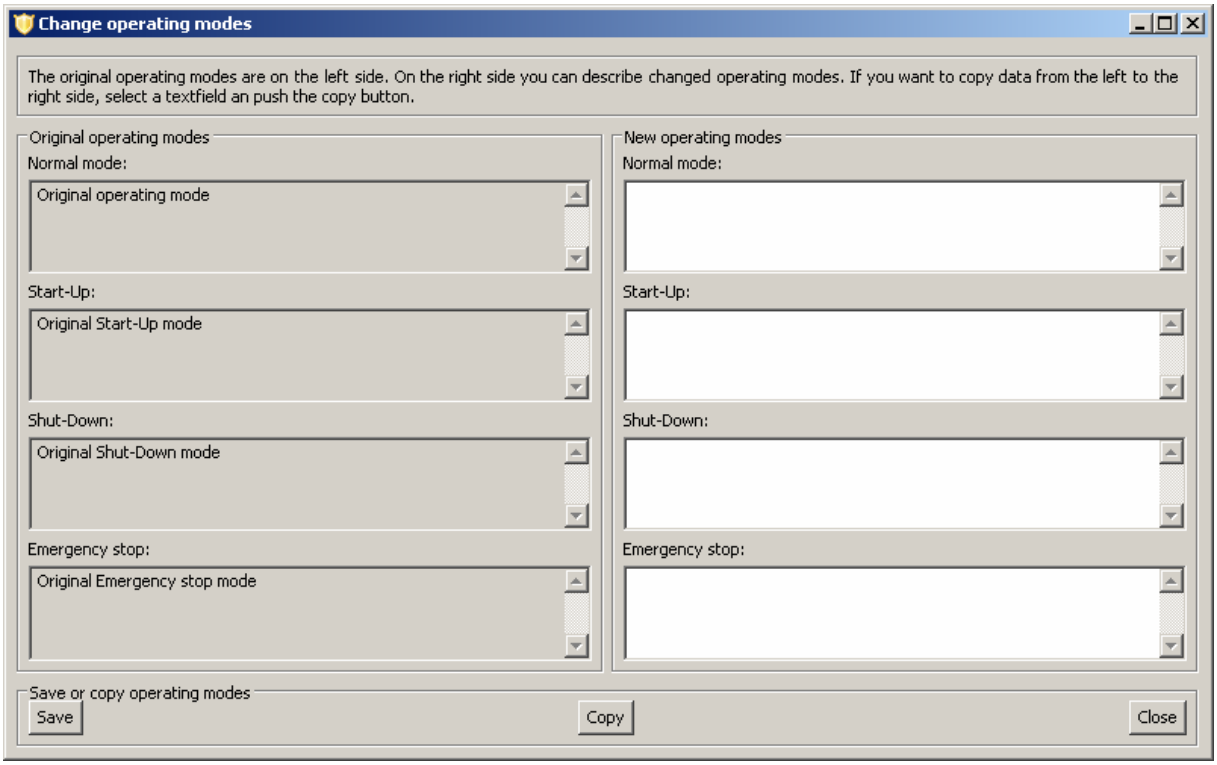


Fig. 12: “Change operation modes”-window

Changes in the operation mode will be part of the documentation of the risk analysis, which will be generated at the summary-window (project tree) for each process function.

5.3. Countermeasures

For all pairs of events and consequences that were assigned for, countermeasures can be taken in the window “Countermeasures”. The procedure of setting countermeasures is shown in the following:

1. Selection of the event/consequence
2. Creation of the countermeasure:
    a. Name (text field)
    b. Selection of a category (organizational, technical, constructive, process control strategy)
    c. Add
    d. Changing of the probability (lowering) due to the new countermeasure

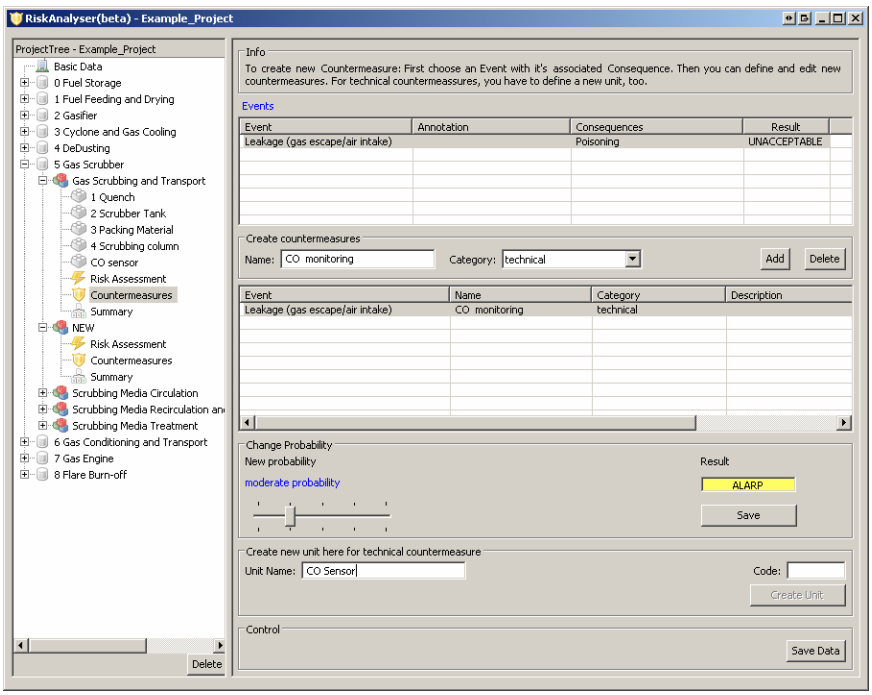


Fig. 13: Setting of countermeasures

Technical countermeasures may involve new units (plant parts). These units can easily be created at the bottom of the “countermeasures”-window.
At the end of the risk assessment, when you enter the “Summary” window the user is asked, whether the new assigned units have also been considered and evaluated in the risk analysis (see Fig. 14).

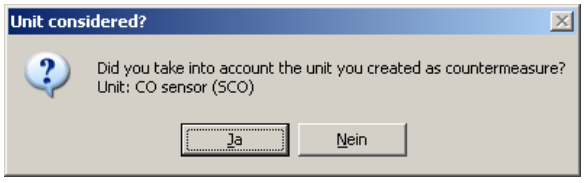


Fig. 14: Question dialog for consideration of new units

6. Reporting

6.1. Summary (for each function)

At the present beta version reports can be automatically generated for each function. A so-called “Function summary” is generated by pressing the “create report”-button in the lower part of the screen. Again operating modes (new after changes through risk analysis) can be edited in this window. Additionally also a list of all countermeasures for risk minimizations is given at the right side of the window.

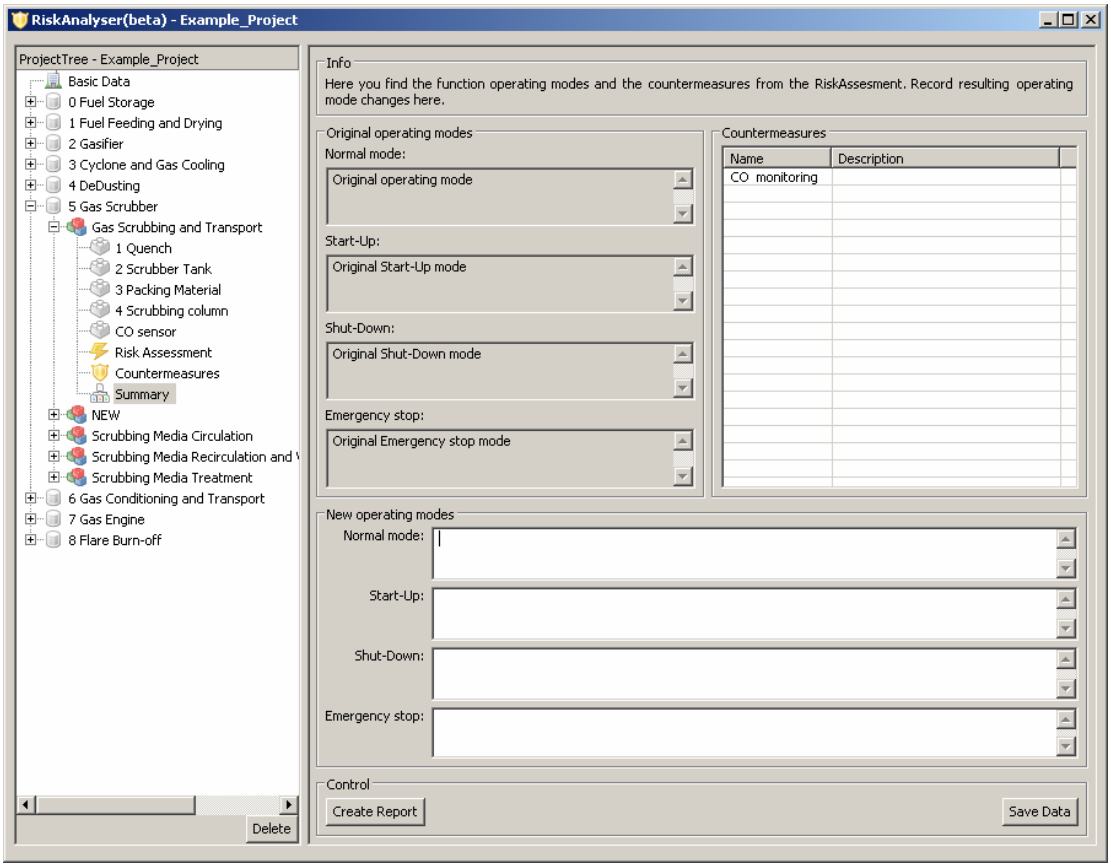


Fig. 15: Reporting of Risk assessment with countermeasures applied

The summary report is generated as a pdf-document in <ProgramFolder>\reports with the name Reports_<FunctionName> and consists of the following points:

- Name
- Function description
- Original operation modes
- Unit descriptions
  - General description
  - Design parameters
  - Auxiliary media (with media parameter)
- … (all units)
- Risk Assessment
- Events and consequences (sorted by events)

- If countermeasures were applied, these are documented and the improvement of the risk (before and after) is shown (see Fig. 16).

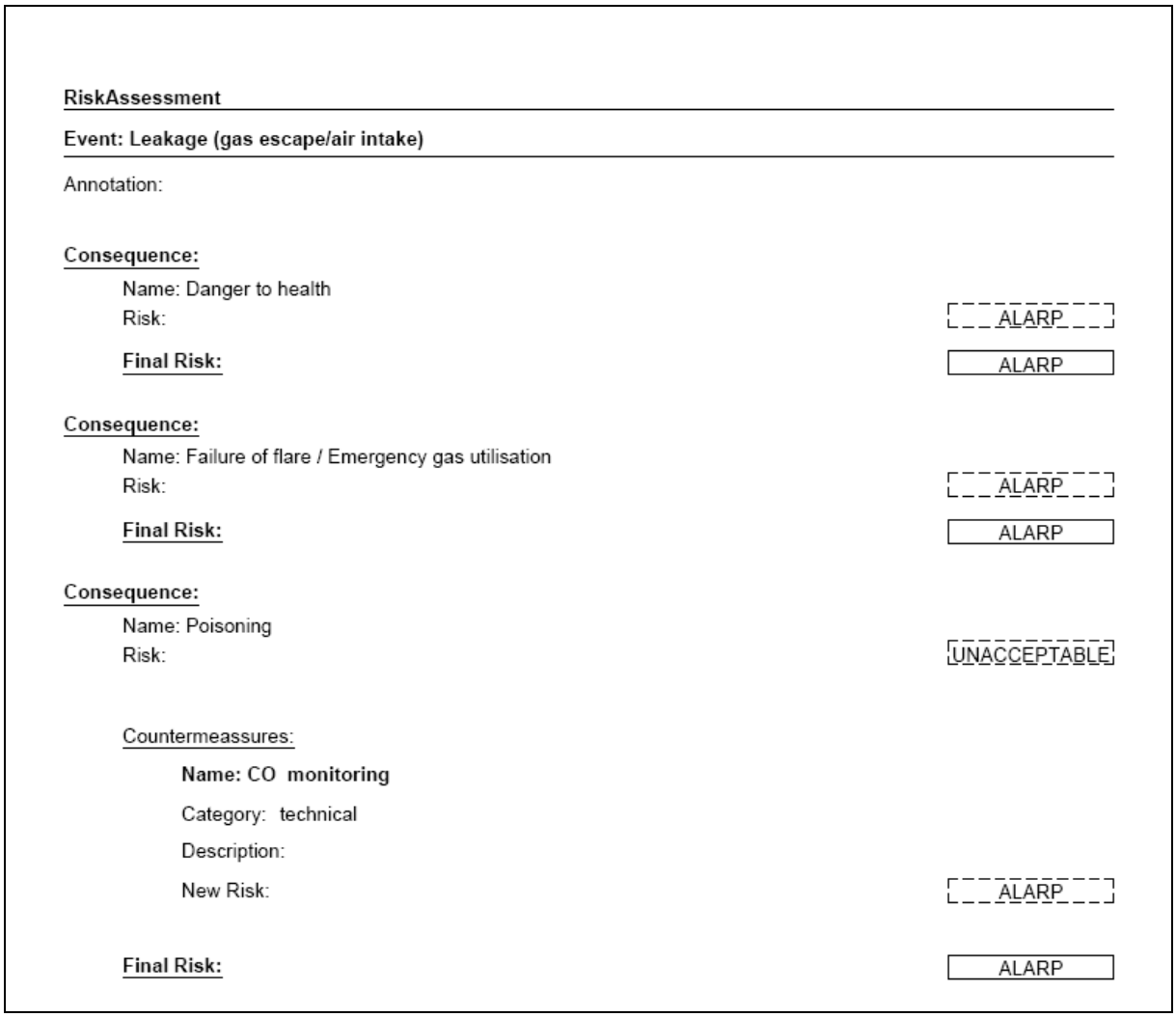


Fig. 16: Reporting of Risk assessment with countermeasures applied

6.2. Reporting in general

Annotation of the programmer:

In the area of reporting there is still big potential for improvement of this beta version of the RISK ANALYSER. Principally, the underlying framework allows great flexibility in the design of the reporting sheets and the file formats (pdf, xml, rtf, etc). Recommendations are highly welcome.

7. References

[1] "Gasification Guide", Guideline for safe and eco-friendly biomass gasification, project no. EIE-06-078, www.gasification-guide.eu, in process.

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8. Annex A - Default list of events and consequences

Table I: Default list of events

i	name	description
1	Leakage (gas escape / air intake)	The term leakages includes the types of unpredictable loss of containment of plant media and plant utilities. Plant media could be biomass, producer gas, scrubbing agent, etc. Plant utilities are possibly pressurised air, cooling agents, inertisation media like nitrogen, etc.
2	Leakage steam	
3	Leakage liquids (escape)	
4	Leakage scrubbing agents	
5	Leakage solids	
6	Temperature too high/low	Physical/chemical parameters gives defined operation conditions of the particular investigated functional group - an exceeding or undershooting of this normal operation conditions could principally lead to hazards and should therefore be investigated as for "too high" or "too low".
7	Pressure too high/low	
8	Plant flows too high/low	
9	Plant fill level too high/low	
10	Concentration too high/low	
11	Failure - mechanical stress	Part or functional group failure can have various shape, depending on operation conditions or mechanical, thermal or chemical stress.
12	Failure - thermal stress	
13	Failure - corrosion	
14	Failure - icing	
15	Failure - ware out	
16	Failure - blocking	
17	Failure - sealing	
18	Failure - welding	
19	Failure - fitting or flange	
20	Hot surfaces	Thermal conversion plants possess system immanent hot surfaces, which have to be analysed due to possible hazards, f.i. gasifier, gas engine exhaust gas system, etc.
21	Failure - electric power supply	Failure in electrical installations, devices or plant steering and control system could be a initial points for a huge number of possible hazards in fully automated plant concepts. Therefore a comprehensive analyse on that topic have to be applied according to the listed points of this rubric.
22	Failure - electric plant steering and control	
23	Failure - electrical device	
24	Failure - sensor	

i	name	description
25	Failure - plant media/utility supply and disposal	The reliable supply with plant medias and plant utilities is necessary for the safe and stable plant operation. Failures within the supply chain could lead to transient operation states (shut down) or failure of safety functions.
26	Harmful plant media and utilities	Biomass Gasification plants process different medias and utilities, which could be harmful for human health and environment. A possible loss of containment (see also leakage) could directly result in health or environmental impairment.
27	Transient operation - start-up	Transient plant operation states includes start-up, shut down and changes of plant power load, where grave intervention into the plant control parameters, applied by the operator or automatic routines, take place.
28	Transient operation - shut-down	
29	Transient operation - increase plant power load	
30	Transient operation - emergency shut-down	
31	Operating error	Operating error are frequent reasons for hazardous consequences within plant operation, so the plant concept should therefore be analysed on such possibilities and further improvement to prevent maloperation (process automation, technical precaution - fail-safe)
32	Maintenance	
33	Force of nature - flooding	Forces of nature have generally to be considered and focuses on the reliability of the process chain under such environmental influences.
34	Force of nature - stroke of lightning	
35	Force of nature - storm/thunderstorm	
36	Force of nature - earthquake	

Table II: Default list of consequences

i	name	description
1	Abnormal operation conditions	Abnormal operation conditions are typically described by exceeding/undershooting of normal operation conditions and physical/chemical media properties and can have various reason.
2	Mechanic failure	This term contains various types of possible failure and failure reasons - see also event list.
3	Danger from electricity	Danger from electricity includes hazards, where electrical installation and their possible malfunctions are involved.
4	Failure gas engine / Emergency stop	Biomass conversion plants (gasification, combustion) process solid, liquid and/or gaseous fuels and have to guarantee a safe utilisation of varying feedstock and under different plant operation states (normal operation, start up, shut down, etc.)
5	Failure of combustion system	
6	Failure of flare / Emergency gas utilisation	
7	Failure of automation system	The stable operation of the automation system assume a functioning process electric system; f.i.: unpredictable failure from plant sensor could lead to an total or part-wise failure of the automation system.
8	Danger to health	Possible dangers to health and impact on environment are summarised within this rubric.
9	Danger to health - skin burns	
10	Danger to health - irritation of skin mucous membrane	
11	Noise pollution, ototoxic noise	
12	Immission (exhaust, flue gas and smell/odour)	
13	Poisoning	
14	Smouldering fire	Fire and explosion are, apart from danger to health or environment, consequences with an almost always high severity. This type of consequence requires in most of cases counter measures and an extended safety concept for successful risk reduction - see risk assessment.
15	Fire	
16	Explosion	
17	Failure of function	Functions failure means the occurance of and specific function of the investigated unit or sub unit, which leads to fatal errors in the process chain.
18	others	

9. Annex B - Examples for Function summary

Function Summary

Name: Gas Scrubbing and Transport (SC1)

Function Description:

Original operating modes:

Normal mode:

Start-Up:

Shut-Down:

Emergency stop:

RiskAssessment

Event: Leakage (gas escape/air intake)

Annotation:

Consequence:

Name: Danger to health

Risk: ALARP

Final Risk: ALARP

Consequence:

Name: Failure of flare / Emergency gas utilisation

Risk: ALARP

Final Risk: ALARP

Consequence:

Name: Poisoning

Risk: UNACCEPTABLE

Countermeassures:

Name: CO monitoring

Category: technical

Description:

New Risk: ALARP

Final Risk: ALARP